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HEAT OF VAPORIZATION OF WATER AT 50°, 70°, AND 90° C.

By E. F. Fiock and D. C. Ginnings

ABSTRACT

The values of the heat of vaporization of water at 50°, 70°, and 90° C. have been determined as 2,381.6, 2,333.6, and 2,283.4 international joules per gram. These results were obtained subsequent to the publication of a detailed report on calorimetric determinations of thermal properties of saturated water and steam. The measured values below 100° are in excellent agreement with those obtained by extrapolation from the measurements above 100° C.

Thermal properties of saturated water and steam in the range from 0° to 270° C., as measured at this bureau, have already been published.[1] The determinations of heat of vaporization given before extended from 100° to 270° C. Since the publication of the first paper it has been possible to extend the measurements of heat of vaporization down to 50° C. These measurements have been carried out under the direction of N. S. Osborne and H. F. Stimson. This brief report is given as a supplement to the previous detailed description. The apparatus, manipulation, notation, and reduction of the data are essentially unchanged.

The results of the more recent experiments are given in detailed form in Table 1.

[1] B. S. Jour. Research, vol. 5 (RP209), pp. 411–480, 1930.

TABLE 1.—*Principal data from γ experiments below 100° C.*

$$\gamma_1=\frac{1}{\Delta M}\left\{Q_E+Q_P+Q_L-[Z+M_2\alpha]_1^2\right\}+\frac{\Delta H'}{\Delta\theta}(\theta_1-\theta_m)$$

Experiment No.	Date	Initial temperature θ_1	Final temperature θ_2	Total time of experiment	Mass of vapor removed ΔM	Mass of water remaining M_2	Total electric energy Q_E	Pump energy Q_P	Heat leak Q_L	Energy correction for final temperature difference $-[Z+M_2\alpha]^2_1$	Entire energy added	Entire energy per gram γ_1	γ_θ Corrected to even temperature	Residual $\gamma_\theta-\gamma_m$
		°C.	°C.	Minutes	g	g	Int. joules	Int. joules	Int. joules	Int. joules	Int. joules	Int. joules/g	Int. joules/g	Int. joules/g
290-A	Aug. 7, 1930	50.074	50.084	42	18.721	391.0	44,446.3	166.7	0.0	−24.4	44,588.6	2,381.7	2,381.9	−0.1
290-B	do	50.080	50.088	30	13.478	366.5	32,015.9	119.1	.0	−19.3	32,115.7	2,382.8	2,383.0	1.0
290-C	do	50.068	50.076	40	17.971	330.5	42,651.4	158.8	.0	−16.7	42,793.5	2,381.2	2,381.4	−.6
291-A	Aug. 8, 1930	50.043	50.049	41	18.391	285.4	43,650.5	162.8	.0	−13.9	43,799.4	2,381.6	2,381.7	−.3
291-B	do	50.049	50.049	40	17.938	267.5	42,556.4	158.8	.0	1.4	42,716.6	2,381.3	2,381.4	−.6
291-C	do	50.049	50.033	40	17.935	249.5	42,532.2	158.8	.0	29.9	42,720.9	2,382.0	2,382.1	.1
291-D	do	50.033	50.040	40	17.910	231.6	42,519.1	158.8	.0	−12.2	42,665.7	2,382.2	2,382.3	.3
291-E	do	50.040	50.028	40	17.919	213.7	42,509.2	158.8	.0	21.5	42,689.5	2,382.4	2,382.4	.4
291-F	do	50.028	50.023	40	17.910	195.8	42,489.0	158.8	.0	9.0	42,656.8	2,381.7	2,381.8	−.2
91-G	do	50.023	50.045	41	18.323	177.5	43,528.7	162.8	.0	−37.1	43,654.4	2,382.5	2,382.5	.5
Even temperature 50° C.		Z_{50}=856 int. joules per ° C.					α_{50}=4.170 int. joules per g ° C.			Mean value of $\gamma_\theta=\gamma_m$=2,382.0 int. joules per g				
292-A	Aug. 11, 1930	70.063	70.062	30	15.235	391.5	35,450.0	111.9	.0	2.8	35,564.7	2,334.4	2,334.6	.7
292-B	do	70.062	70.077	35	17.745	373.8	41,324.8	130.6	5.5	−37.3	41,423.6	2,334.4	2,334.5	.6
292-C	do	70.061	70.066	45	22.810	333.6	53,066.7	167.9	2.8	−11.4	53,226.0	2,333.4	2,333.6	−.3
292-D	do	70.064	70.070	32	16.204	299.2	37,701.3	119.4	1.1	−13.3	37,808.5	2,333.3	2,333.4	−.5
292-E	do	70.056	70.059	32	16.179	267.8	37,627.1	119.4	.2	−5.3	37,741.4	2,332.7	2,332.9	−1.0
292-F	do	70.059	70.063	30	15.245	252.5	35,467.9	111.9	.7	−7.9	35,572.6	2,333.4	2,333.5	−.4
292-G	do	70.063	70.064	30	15.239	237.3	35,464.2	111.9	−1.8	−2.3	35,572.0	2,334.3	2,334.4	.5
293-A	Aug. 12, 1930	70.021	70.014	25	17.852	385.5	41,567.3	93.3	−.7	15.9	41,675.8	2,334.5	2,334.6	.7
293-B	do	70.014	70.006	25	17.857	367.6	41,555.9	93.3	−.7	19.9	41,668.4	2,333.4	2,333.5	−.4
293-C	do	70.006	70.010	25	17.834	349.8	41,548.1	93.3	−.5	−9.0	41,631.9	2,334.4	2,334.4	.5
293-D	do	70.010	70.012	20	14.267	335.5	33,233.7	74.6	.2	−3.7	33,304.8	2,334.4	2,334.4	.5
293-E	do	70.008	70.006	20	14.270	306.9	33,225.1	74.6	.0	4.4	33,304.1	2,333.8	2,333.9	.0
293-F	do	70.006	70.003	20	14.275	292.7	33,222.1	74.6	.0	6.6	33,303.3	2,333.0	2,333.0	−.9

293-G	do	70.003	70.012	20	14.259	278.4	33,218.7	74.6	.2	−18.1	33,275.4	2,333.6	2,333.6	−.3
293-H	do	70.012	70.008	20	14.264	264.1	33,214.9	74.6	−.2	4.5	33,293.8	2,334.1	2,334.1	.2
293-I	do	70.008	70.000	20	14.273	249.9	33,210.9	74.6	−.2	17.1	33,302.4	2,333.2	2,333.3	−.6
293-J	do	70.000	70.008	20	14.255	235.6	33,207.7	74.6	.0	−14.9	33,267.4	2,333.7	2,333.7	−.2
293-K	do	70.006	70.000	20	14.258	186.9	33,196.8	74.6	−.4	9.0	33,280.0	2,334.1	2,334.1	.2
Even temperature 70° C.		Z_{70}=869 int. joules per ° C.			α_{70}=4.169 int. joules per g° C.				Mean value of $\gamma_\theta=\gamma_m$=2,333.9 int. joules per g					
295-A	Aug. 15, 1930	89.925	89.918	20	16.802	312.5	38,298.0	70.6	.7	14.6	38,383.9	2,284.3	2,284.2	.5
295-B	do	89.918	89.918	44	36.892	275.6	84,102.4	155.3	.9	.6	84,259.2	2,283.9	2,283.7	.0
295-C	do	89.918	89.924	20	16.760	285.8	38,224.3	70.6	.0	−11.8	38,283.1	2,284.2	2,284.0	.3
295-D	do	89.924	89.920	26	21.782	237.1	49,671.0	91.8	.2	7.4	49,770.4	2,284.9	2,284.7	1.0
295-E	do	89.920	89.920	20	16.760	220.3	38,191.9	70.6	−.5	−.4	38,261.6	2,282.9	2,282.7	−1.0
295-F	do	89.920	89.916	27	22.602	197.7	51,535.4	95.3	−1.1	8.3	51,637.9	2,284.7	2,284.4	.7
295-G	do	89.916	89.916	20	16.753	180.9	38,169.9	70.6	.0	−1.2	38,239.3	2,282.5	2,282.3	−1.4
Even temperature 90° C.		Z_{90}=885 int. joules per ° C.			α_{90}=4.168 int. joules per g ° C.				Mean value of $\gamma_\theta=\gamma_m$=2,283.7 int. joules per g					

Table 2 shows the reduced results of the experiments at low temperatures. The values of β in column 3 were calculated from the equation $\beta=\frac{Lu}{u'-u}$, using the values of u' given by Keyes and Smith.[2]

TABLE 2.—*Heat of vaporization (L) of water at 50°, 70°, and 90° C.*

Temperature θ	γ observed	β calculated	L	
			Observed	Calculated
°C.	*Int. joules/g*	*Int. joules/g*	*Int. joules/g*	*Int. joules/g*
50	2,382.0	0.2	2,381.8	2,381.6
70	2,333.9	.5	2,333.4	2,333.6
90	2,282.7	1.0	2,282.7	2,283.4

NOTE.—The values of L shown in column 5 were calculated from the equation

$$L=0.002562(374-\theta)^2-5.883(374-\theta)+249.9(374-\theta)^{1/2}-113(374-\theta).^{1/4}$$

This equation, which was fitted to the observed values of heat of vaporization above 100°, holds equally well for the observations down to 50° C.

WASHINGTON, January 6, 1932.

[2] Mechanical Engineering, vol. 53, pp. 132–135; 1931.